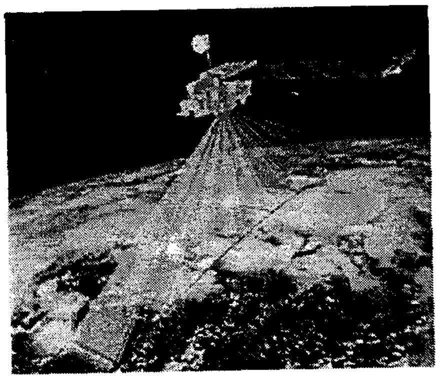
SAFARI 2000 is an international regional science initiative being developed for Southern Africa to explore, study and address linkages between land-atmosphere processes and the relationship of biogenic, pyrogenic or anthropogenic emissions and the consequences of their deposition to the functioning of the biogeophysical and biogeochemical systems of southern Africa. This initiative is being built around a number of on-going, already funded activities by NASA, the international community and African nations in the southern African region.



No instrument like MISR has flown in space before. Viewing the sunlit Earth simultaneously at nine widely spaced angles, MISR collects global images with high spatial detail in four colors at every angle. These images are carefully calibrated to provide accurate measures of the brightness, contrast, and color of reflected sunlight.

The change in reflection at different view angles affords the means to distinguish different types of atmospheric particles (aerosols), cloud forms, and land surface covers. Combined with stereoscopic techniques, this enables construction of 3-dimensional models and more accurate estimates of the total amount of sunlight reflected by Earth's diverse environments.

MISR provides new types of information for scientists studying Earth's climate, such as the partitioning of energy and carbon between the land surface and the atmosphere, and the regional and global impacts of different types of atmospheric particles and clouds on climate.

MISR was built for NASA by the Jet Propulsion Laboratory. It is part of NASA's Terra spacecraft, launched into a polar orbit around Earth on 18 December, 1999.

For latest status on MISR, go to News section (updated 10 July, 2000)

MISR data products are distributed through the NASA Langley Atmospheric Sciences Data Center

UNPRECEDENTED FIRE SEASON IN SOUTHERN AFRICA AIDS AIR QUALITY, CLIMATE CHANGE RESEARCH

The fires that raged across southern Africa this August and September produced a thick "river of smoke" that observers compared with the aftermath of the Kuwaiti oil fires in 1991. NASA-supported studies currently underway on the event will contribute to improved air pollution policies in the region and a better understanding of its impact on climate change.

"Every year African biomass burning greatly exceeds the scale of the fires seen this year in the western United States," says Robert Swap of the University of Virginia, one of the organizers of the Southern African Regional Science Initiative (SAFARI 2000) field campaign. "But the southern African fire season we just observed may turn out to be an extreme one even by African standards. It was amazing how quickly this region went up in flames."

The intensive SAFARI 2000 six-week field campaign was planned to coincide with the dry-season fires. The experiment included observations from NASA's Terra and Landsat 7 spacecraft, research aircraft including NASA's ER-2 high-altitude jet, and several ground stations. Over 200 scientists from around the world participated in the campaign, which ended Sept. 25.

This year the southern African fire season peaked in late August and early September. The region is subject to some of the highest levels of biomass burning in the world. SAFARI 2000 planners tracked the changing location of fires with daily satellite maps provided by researchers at NASA's Goddard Space Flight Center (Greenbelt, Md.). The heaviest burning was in western Zambia, southern Angola, northern Namibia, and northern Botswana. Some of the blazes had fire fronts 20 miles long that lasted for days.

The thick haze layer from these fires produced between Aug. 23 and Sept. 7 was heavier than campaign participants had seen in previous field studies in the Amazon Basin and during the Kuwati oil fires.

"We observed a river of smoke that moved from northwest to southeast over the subcontinent, causing heavy haze and reduced visibility over Botswana and South Africa for about ten days in early September," says SAFARI 2000 organizer Harold Annegarn of the University of the Witwatersrand, Johannesburg.

According to veteran pilot Ken Broda, who flew NASA's ER-2 above the haze layer, "this was probably the worst in-flight visibility I've seen anywhere, even during the oil fires following the Persian Gulf War. From the ER-2's altitude of 60,000 feet, where normal visibility can stretch 60 miles, I couldn't clearly see the city of Johannesburg until I was directly overhead."

With instruments on the ground, in the air, and in space, scientists were able to sample the chemistry and measure the thickness of the smoke plumes, map the movements of the haze layer, and investigate how the smoke and fine aerosol particles affect clouds.

"For the first time we were able to track this annual haze from its source and determine what happens to the aerosols in the haze," says Annegarn. "The measurements we have now of carbon transport in the haze, both as gases and particles, will add important pieces to balancing global carbon budgets."

Studies by research aircraft flying inside the pall of haze revealed several surprises. Aircraft encountered puzzling layers of extremely clean air sandwiched between polluted layers.

"The pollution in the region is often very stratified with height in the atmosphere," says Peter Hobbs of the University of Washington, principal investigator for the experiments onboard the university's Convair-580 aircraft. "Regions of heavy pollution were separated by a very thin - just a few hundred feet deep - layer of almost pristine air."

The haze aerosols sampled were also more heat-absorbing than expected, which means the haze layer may have a significant warming influence on the region's atmosphere. "The aerosol in the region was surprisingly absorbing," says Hobbs. "Such aerosols may well add to the greenhouse warming effect, particularly in the mid-troposphere. Most aerosols are thought to offset that warming by scattering incoming solar radiation back into space."

The thick haze also contained high levels of ozone, a component of smog, that frequently reached levels similar to those found during air pollution alerts in major U.S. cities. Making the first balloon-borne measurements of ozone during the height of a southern African burning season, Goddard scientist Anne Thompson found that the impact of the haze may be greater on climate change than on human health.

"Ozone levels in U.S. urban centers may be more unhealthy at the ground, but the ozone profiles we took in Zambia show that much of the ozone here is in the middle and upper troposphere where ozone's 'badness' is its effect as a greenhouse gas," says Thompson.

New air quality data collected during the campaign will also help governments in the region develop future environmental policies. Annegarn and other South African scientists are working to distinguish the industrial sources of air pollution from natural sources such as emissions from vegetation and soils.

"With the SAFARI 2000 data we now have the first comprehensive measurements of aerosols from the major industrial sources in southern Africa," said Annegarn. "Together with the detailed chemical analyses of these sources gathered during the campaign, we can now evaluate the relative importance of industrial emissions in the region's air pollution, which will contribute to the development of both national and regional air quality management policies."

U.S. participation in the SAFARI 2000 campaign was sponsored by NASA's Earth Observing System (EOS) project, a suite of spacecraft and interdisciplinary science investigations dedicated to advancing our knowledge of global change. EOS is managed by Goddard Space Flight Center for NASA's Earth Science Enterprise. A key objective of this year's campaign was to acquire measurements for validating new data products from NASA's Terra spacecraft.

Photographs of South African fires and SAFARI 2000 field activities supporting this story are available at:
http://www.gsfc.nasa.gov/gsfc/earth/environ/safari2000final.htm

More information on the SAFARI 2000 project is available at:
http://safari.gecp.virginia.edu/

This text derived from
http://www.gsfc.nasa.gov/gsfc/earth/environ/safari2000final.htm

Date	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	20-Aug	21-Aug
Flight Scientist	M. King	M. King	M. King	M. King		M. King	
MISR Orbit	3509	3524	3538	3553	3568	3582	3597
AirMISR Sortie							
Aircraft			ER-2			ER-2	
	CV-580		CV-580	CV-580		CV-580	
	JR-A	JR-A		JR-A		JR-A	
	JR-B	JR-B				JR-B	
Ground	Tower		Tower				
Instruments	Samplers	Samplers	Samplers			Samplers	
	Radiometry	Radiometry	Radiometry		Radiometry		Radiometry
	Atm.Profile	Atm.Profile	Atm.Profile				
Targets	Skukuza	Mongu,	Skukuza,	Madikwe	Etosha	Salibe-	Etosha
		Richard's-	Inhaca Is.		WalvisBay	Phekwe,	
		Bay	Ind. Ocean			Madikwe	
MISR Cal/Val @				Sua Pan	Sua Pan	Sua Pan	Sua Pan

22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug
M. King		M. King	M. King	M. King	M. King		M. King	
3611	3626	3640	3655	3669	3684	3699	3713	No good
ER-2		ER-2	ER-2		ER-2		ER-2	
CV-580		CV-580					CV-580	
JR-A		JR-A		JR-A	JR-A		JR-A	
JR-B		JR-B	JR-B	JR-B	JR-B		JR-B	
Tower			Tower		PARABOLA		Tower	
Samplers			Samplers		Samplers		Samplers	
Radiometry	Radiometry	Radiometry	Radiometry	Radiometry	Radiometry	Radiometry	Radiometry	
Atm.Profile			Atm.Profile		Atm.Profile			
Skukuza,	Zambezi	Malawi,	Kaoma,	Nampula,	Sua Pan,	Etosha	Gauteng,	
Satara,		Maputo,	Sua pan,	Kasane	Okavango,	WalvisBay	Skukuza,	
Witbank		Inhaca Is.	Maun		Maun		Inhaca Is.	
Sua Pan	Sua Pan	Sua Pan	Sua Pan	Sua Pan	Sua Pan	Sua Pan	Sua Pan	Sua Pan

31-Aug	1-Sep	2-Sep	3-Sep	4-Sep	5-Sep	6-Sep	7-Sep	8-Sep
C. Moeller	C. Moeller	C. Moeller	C. Moeller	C. Moeller	C. Moeller	C. Moeller	C. Moeller	
3742	3757	3771	3786	3801	3815	3830	3844	3859
						00-157	00-158	
ER-2	ER-2			ER-2		ER-2	ER-2	
CV-580	CV-580		CV-580		C-130	C-130	C-130	
	JR-A	JR-A			JR-A	JR-A	JR-A	
JR-B		JR-B	JR-B					
Tower	Tower	Tower	PARABOLA				Tower	
Samplers	Samplers	Samplers	Samplers			Samplers	Samplers	Samplers
Radiometry	Radiometry	Radiometry	Radiometry	Radiometry	Radiometry	Radiometry	Radiometry	Radiometry
Atm.Profile	Atm.Profile	Atm.Profile				Atm.Profile	Atm.Profile	Atm.Profile
Skukuza,	Skukuza,	Maun,	Sua Pan	Sua Pan,	N.Province	Mongu,	Skukuza	Mongu,
Limpopo,	ER-2 Night	Rich'sBay,		(ER-2 Only)	Namibian	Kaoma,	Nam. coast	Zambezi
Rio Save	Targets	Nampula		WalvisBay	coast	Senanga	Timbavati	
Sua Pan	Sua Pan	Sua Pan	Sua Pan	Sua Pan				

9-Sep	10-Sep	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep
		S. Platnick		S. Platnick	S. Platnick		S. Platnick	S. Platnick
3873	3888	3903	3917	3932	3947	No good	3975	3990
				00-175	00-176			
		ER-2		ER-2	ER-2			ER-2
		C-130		C-130	C-130		C-130	
		CV-580		CV-580	CV-580			JR-A
Tower	Tower						Tower	Tower
Samplers	Samplers						Samplers	Samplers
Radiometry	Radiometry	Radiometry		Radiometry	Radiometry		Radiometry	Radiometry
Atm.Profile	Atm.Profile						Atm.Profile	Atm.Profile
Skukuza	Mongu,	Namibian	Sua Pan,	Etosha,	Etosha,		Skukuza,	Maun,
Chobela	Maun,	Stratus	Mzola,	Namibian	Namibian		Inhaca Is.	Mongu,
Inhaca Is.	Kasane	WalvisBay	Ndola	Stratus	Stratus		Mutoko	Zambezi
					Skukuza	Skukuza	Skukuza	Skukuza

18-Sep	19-Sep	20-Sep	21-Sep	22-Sep	23-Sep	24-Sep	25-Sep	26-Sep
			S. Platnick		S. Platnick		S. Platnick	
4004	4019	4034	4048	4063	4077	4092	4106	4121
			ER-2		ER-2		ER-2	
			JR-B		JR-A			
					Tower		Tower	Tower
					Samplers	Samplers	Samplers	Samplers
Radiometry		Radiometry	Radiometry	Radiometry	Radiometry	Radiometry	Radiometry	Radiometry
					Atm.Profile	Atm.Profile	Atm.Profile	Atm.Profile
Nampula	Kasane,	WalvisBay	Ind. Ocean	Etosha	Skukuza,	Mongu,	Skukuza,	Mongu,
	Sua Pan,		Highveld		Bethlehem	Zambezi	Malawi,	Maun,
	Solwezi		Sites				Inhaca Is.	Ghanzi
Skukuza	Skukuza	Skukuza	Skukuza	Skukuza	Skukuza	Skukuza	Skukuza	Skukuza

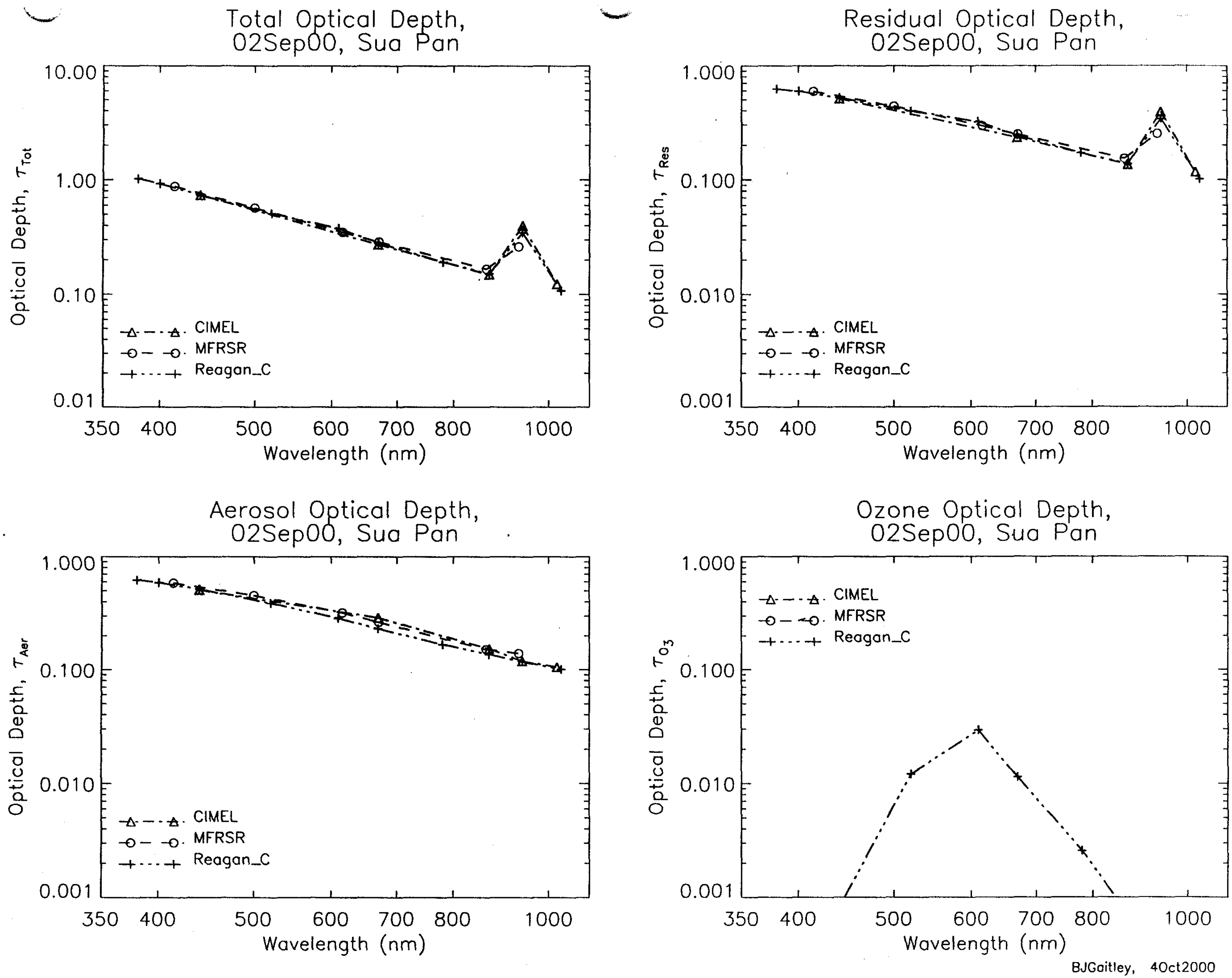
27-Sep	28-Sep	29-Sep	30-Sep	1-Oct	2-Oct	Date
						Flight Scientist
4135	4150	4165	4179	No good	4208	Terra Orbit
						AirMISR Sortie
						Aircraft
					PARABOLA	Ground
					Tower	Instruments
Radiometry		Radiometry			Radiometry	
Nampula	Sua Pan,	Etosha	Mfuwe,		Skukuza	Targets
	Mzola,	WalvisBay	Mutoko,			
	Ndola		Zaka			
Skukuza	Skukuza	Skukuza	Skukuza	Skukuza	Skukuza	MISR Cal/Val @

Table 1: Data Inventory, Sua_Pan

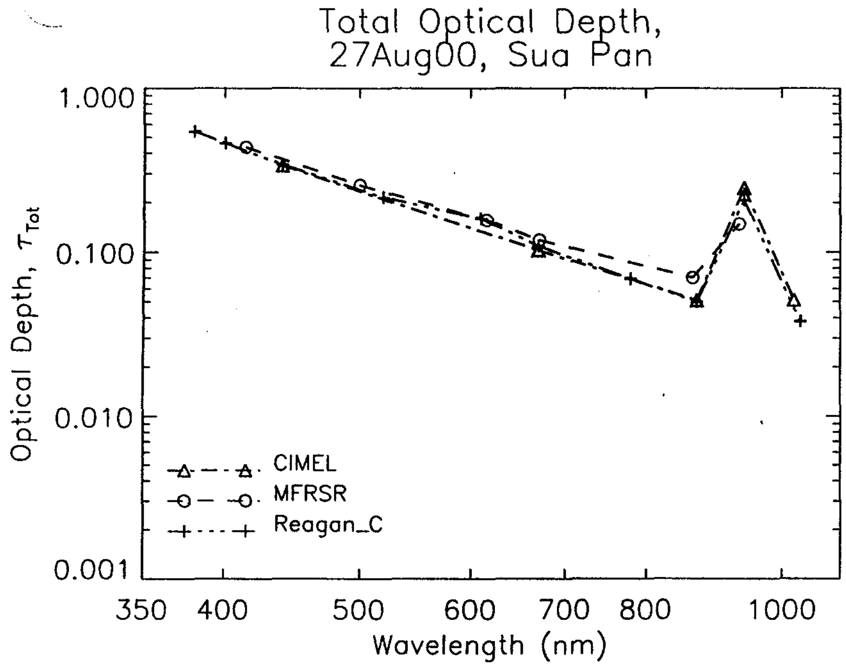
	MISR	PARAB-OLA	ASD	CIMEL	MFRSR	Reagan	Met Station
Aug 18	Orbit 3553, 08:48 UT					✔	
Aug 19			✔			✔	✔
Aug 20				✔			✔
Aug 21				✔	✔	✔	✔
Aug 22				✔		✔	✔
Aug 23				✔		✔	✔
Aug 24				✔	✔	✔	
Aug 25			✔	✔	✔	✔	✔
Aug 26				✔	✔	✔	✔
Aug 27	Orbit 3684, 08:42 UT	✔	✔	✔	✔	✔	✔
Aug 28				✔	✔	✔	✔
Aug 29				✔	✔	✔	✔
Aug 30		✔	✔	✔	✔	✔	✔
Aug 31				✔	✔	✔	✔
Sep 01		✔		✔	✔	✔	✔
Sep 02				✔	✔	✔	✔
Sep 03	Orbit 3786, 08:48 UT	✔	✔	✔	✔	✔	✔
Sep 04		✔		✔	✔	✔	✔

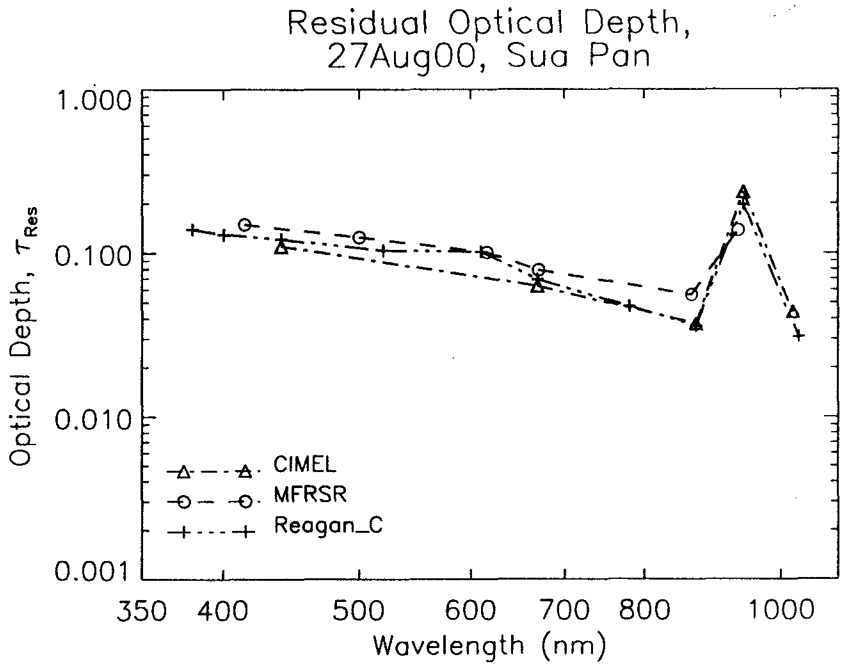
Table 1: Data Inventory, Skukuza

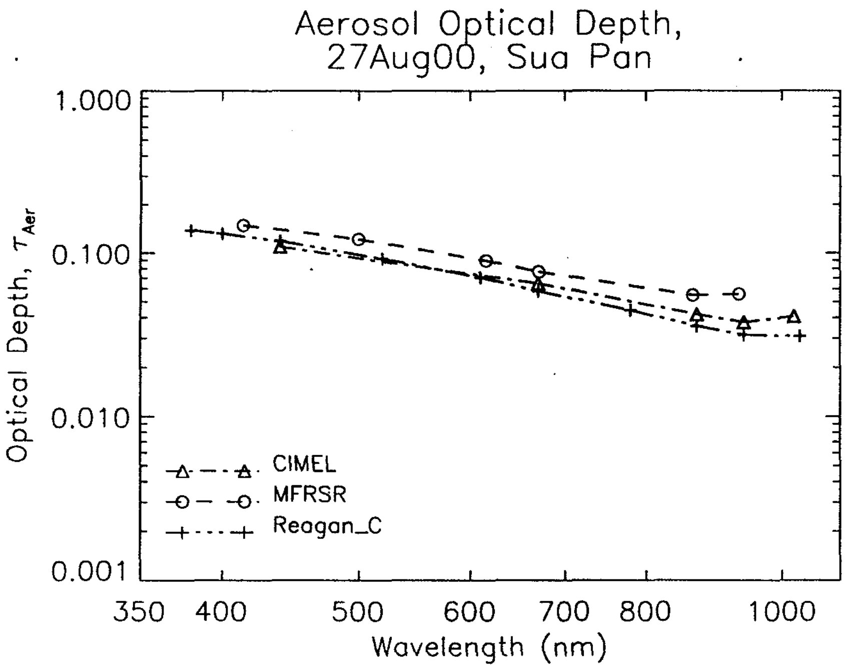
	MISR	PARAB-OLA	CIMEL	MFRSR	Reagan	Met Station
Sep 14			✔	✔	✔	✔
Sep 15			✔			✔
Sep 16	Orbit 3975, 08:18 UT		✔			✔
Sep 17			✔	✔	✔	
Sep 18						
Sep 19						
Sep 20						
Sep 21						
Sep 22						
Sep 23	Orbit 4077, 08:24 UT	✔			✔	
Sep 24			✔			✔
Sep 25	Orbit 4106, 08:12 UT		✔		✔	✔
Sep 26		✔				✔
Sep 27			✔			✔
Sep 28		✔	✔	✔	✔	✔
Sep 29			✔			✔
Sep 30		✔	✔	✔	✔	✔
Oct 01		✔	✔			✔
Oct 02	Orbit 4208, 08:18 UT		✔	✔	✔	✔

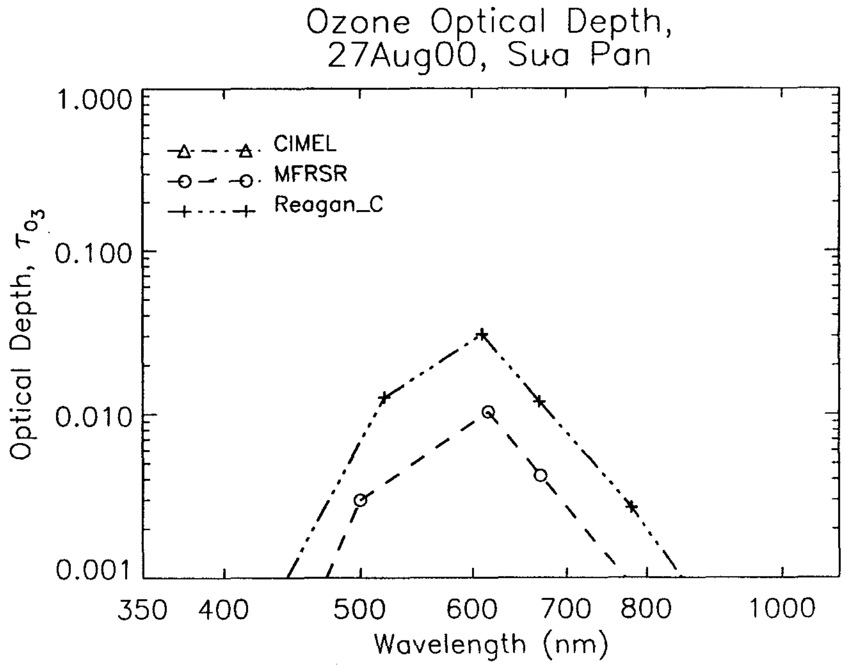


Total Optical Depth, 02Sep00, Sua Pan
Optical Depth, τ_{Tot}
10.00
1.00
0.10
0.01
CIMEL
MFRSR
Reagan_C
Residual Optical Depth, 02Sep00, Sua Pan
Optical Depth, τ_{Res}
1.000
0.100
0.010
0.001
CIMEL
MFRSR
Reagan_C
Aerosol Optical Depth, 02Sep00, Sua Pan
Optical Depth, τ_{Aer}
1.000
0.100
0.010
0.001
CIMEL
MFRSR
Reagan_C
Ozone Optical Depth, 02Sep00, Sua Pan
Optical Depth, τ_{O_3}
1.000
0.100
0.010
0.001
CIMEL
MFRSR
Reagan_C
350 400 500 600 700 800 1000
Wavelength (nm)
BJGaitley, 4Oct2000









BJGaitley, 4Oct2000

Safari 2000

A Southern African Regional Science Initiative

SAFARI 2000

Why Southern Africa?

Central and southern Africa are experiencing large-scale social, economic and ~~political~~ changes that are affecting the land use and land cover across the region?s subtropical, semi-arid and arid ecosystems. Specifically, significant impacts have been caused by increasing populations, population migration, industrial development, water shortages and the widespread practice of less efficient or unsustainable agricultural techniques. For example, increased political stability provided a basis for more rapid economic development. Tourism and the mineral sector of heavy industry, in particular, are expanding rapidly.

The atmosphere of the region is also experiencing significant change. Its thin layer acts as an integrating mechanism whereby locations thousands of kilometres apart are linked through the strength and persistence of a regional circulation feature known as the southern African anticyclonic gyre. The trace gases and aerosols transported within this gyre come from three principal sources: the burning of fossil fuels and other industrial activities; biomass burning in wildfires and domestic hearth fires; and natural processes in the terrestrial and aquatic ecosystems of the region. Specifically, the burning of fossil fuels in mining, industrial and domestic activities are in part responsible for rising levels of atmospheric aerosols and trace gases (Held et al., 1996; Sivertsen et al., 1995).

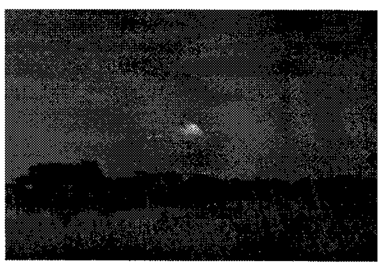
These emissions are augmented by those from some of the most extensive biomass burning in the world, most of which is associated with savanna burning, domestic fuelwood consumption, and agricultural practices (Crutzen and Andreae, 1990; Helas and Pienaar, 1996; Scholes et al., 1996; Justice et al., 1996: Hulme et al., 1997; Chanda et al., 1998). Together with strong biogenic emissions (Harris et al. 1996; Parsons et al. 1996; Levine et al. 1996; Guenther et al. 1996; Thompson et al., 1996), these emissions may be altering the biogeochemical cycling of essential nutrients in the region (Garstang et al., 1998). From preliminary analysis of the available data it appears that no single emission source dominates. This has yet to be rigorously tested, however. Among other phenomena, the interaction and transformation of emissions within the atmosphere contribute to the development of an elevated tropospheric ozone anomaly over the western edge of the sub-continent and adjacent tropical South Atlantic ocean in the late dry season and early spring (Fishman et al. 1991).

Previous research initiatives focused separately on ecological and climate issues contributed much to our understanding of discipline-specific processes. They ~~also stimulated the formulation of~~

also stimulated the formulation of difficult and complex questions that perhaps can only be answered with the coordinated, interdisciplinary approach of SAFARI 2000. Much more attention now needs to be given to understanding the linkages between the controlling and impacted processes, particularly those occurring over relatively large spatial and temporal scales.

Background

In 1992 NASA participated in the Trace - A / Southern Africa Fire - Atmosphere Research Initiative (SAFARI) 1992 (Andreae et al. 1994). SAFARI 92 was the Southern African component and focused on the factors controlling the process and distribution of biomass burning as well as the chemistry, transport and source strength of the products of biomass burning (Lindesay et al. 1996). During SAFARI several partnerships were developed between US and southern African scientists. The continued development of these relationships has culminated in the proposed SAFARI 2000 experiment. SAFARI was chosen as a rallying acronym for the initiative, centered on the millennium and with a heritage of international collaboration within the region. The project has met with preliminary endorsement from the IGAC BIBEX group, the original umbrella organization for the SAFARI 92 campaign. From the NASA side the activity will be similar to the SCAR (Smoke Cloud Aerosol and Radiation) experiment series (Kaufman et al. 1998) involving aircraft and in situ experiments but with stronger terrestrial ecosystems, land cover and land use change and satellite validation components than before.



Central and southern Africa have undergone and continue to undergo large changes in social, economic and political environments that contribute to large-scale changes in land use and land cover within their respective ecosystems. The opening up of southern Africa due to the absence of war and political strife has led to economic development, especially in the sector of heavy industry. Energy generation to drive mining and metallurgical industries, as well as the industrial processes themselves, contribute to high levels of aerosol and trace gas emissions (Held et al., 1997; Sivertsen et al., 1995). Additionally, this region of Africa is subjected to some of the highest degrees of biomass burning in the world, most of which is associated with human population pressures on regional ecosystems (Crutzen and Andreae, 1990; Helas and Pienaar, 1996; Scholes et al., 1996; Justice et al., 1996). These anthropogenic perturbations, along with a strong, largely understood source of biogenic emission processes (Harris et al. 1996; Parsons et al. 1996; Levine et al. 1996; Guenther et al. 1996) and a large natural variability in both regional climate and ecosystem processes combine, primarily through manipulation of surface aerosol and trace gas emissions, to effect changes in the biogeochemical cycling of the region.

In addition to the partnerships developed during and after SAFARI-92, much progress has been made recently in scientific research concerning changes in land cover and land usage, atmospheric circulations and transports, biogeochemistry, and ecosystem functioning, in southern and central Africa. The implementation of the IGBP Terrestrial Transects program (Koch et al., 1995), the creation of the IGBP Miombo network (Desanker et al. 1997), the IGBP Kalahari Transect (Scholes and Parsons, 1997), the IGBP BIBEX (Biomass Burning Experiment) SAFARI/TRACE-A field campaigns (Andreae et al., 1994; Lindesay et al., 1996; Fishman et al., 1996), the formation of the Southern African Atmospheric Research Initiative (SAARI) alliance as well as the involvement of IGAC's Biosphere-Atmosphere Trace Gas Exchange in the Tropics (BATGE; Guenther et al. 1995; 1996) and Deposition of Biogeochemically Important Trace Species (DEBITS) programs within the region are all examples of such progress.

Although these projects have all contributed to the understanding of discipline-specific objectives, exploration of linkages between and the integration of information from each of the specific disciplines to form a more complete and interdisciplinary understanding of the functioning of southern and central Africa ecosystems and the regional atmosphere has been lacking. It is envisaged that advances in the understanding and modeling of the biogeophysical systems associated with NASA EOS validation activities, as they relate to regional and global environmental change in southern Africa, will result from an interdisciplinary approach that involves international collaboration.

airborne, and satellite-based observations; and determine the climatic, hydrological, and ecosystem consequences of these biogeochemical processes.

Interest in the southern African region by the EOS validation community stems from two basic reasons: 1) unique and compelling scientific processes highly relevant to understanding climate and global change and 2) ongoing scientific investigations funded by southern African, European, and U.S. sponsors. The latter create the opportunity for leveraging off existing investigations, thereby providing maximum scientific return on limited resources.

The Region

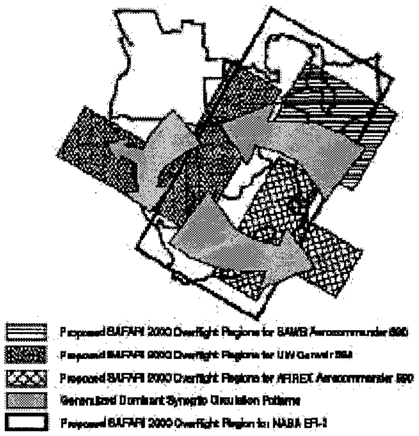


Figure 1. Southern African Recirculation Patterns and Potential Airborne Sampling Areas.

The boundaries of the study region are defined by the atmospheric environment and the geography of Africa south of the Equator. These permit a reasonably discrete study region, which in turn permits mass-balance calculations to be performed. The semi-closed atmospheric circulation, shown in Figure 1, provides both a context and integrating mechanism between the biological and physical systems. This is especially the case during austral winter when anticyclonic circulation and associated clear sky conditions favorable for satellite and airborne remote sensing, dominate the region on as many as four out of every five days.

Marked biogeophysical gradients in vegetation type and structure, rainfall, and biogeochemistry characterize much of the study region. These gradients occur over spatial extents of thousands of kilometers both meridionally, as in the case of the Kalahari sands, and zonally, as is the case of the Miombo woodlands. The latter, which represent the largest tropical dry forest system in the world, occupies approximately 2.8 million km^2 in Africa. Both rainfall, which varies annually across the region from <100 mm to >1200 mm, and fire occurrence and frequency demonstrate a strongly seasonal, generally temporally consistent, spatial progression across the study region. The wet season extends from November through May. Fire frequency peaks in August/September, coincident with the peak of the dry season (Figure 2).

Background

Southern Africa is a highly sensitive region due to its increasing population and population migration, rain-fed subsistence agriculture, limited water and food availability, and relatively low industrial development. However, recent political and social stability has led to more rapid though sporadic economic and industrial development. Energy generation to support mining and metallurgical industries, as well as the industries themselves, has contributed to high levels of aerosol and trace gas emissions. Additionally, the region is subject to some of the most extensive biomass burning in the world, most of which is associated with human population pressures on regional ecosystems. These anthropogenic forces, along with a strong source of biogenic emissions and a large natural variability in both regional climate and ecosystem processes, combine to effect changes in the biogeochemical cycling of the region. Moreover, these forces serve as strong catalysts for large-scale changes in land cover and use.

These threats to the regional ecology and climate have led the Intergovernmental Panel on Climate Change (IPCC) and the International Geosphere-Biosphere Program (IGBP) to designate southern Africa as a focus for scientific assessment. Specifically, the IGBP and START (SysTem for Analysis, Research, and Training) have facilitated collaborative research efforts through their Kalahari, Miombo, and Subsistence Rangelands programs. Other national and international agencies such as the NOAA Climate Prediction Forum and Regional Applications Program have likewise targeted the region.

The international science community has mounted a concerted response. The Southern African Fire-Atmosphere Research Initiative 1992 (SAFARI 92) was organized under the IGAC (International Global Atmospheric Chemistry) Biomass Burning in the Global Environment (BIBEX) program. The activity involved more than 150 scientists from 14 countries and focused on biomass burning and its atmospheric effects in the Southern Hemisphere. It particularly addressed factors controlling the process and distribution of subtropical savanna fires as well as the chemistry, transport and source strength of their products. The successful program contributed substantially to our current understanding of these processes, although SAFARI 92 revealed little on their consequences.

The Southern African Atmosphere Research Initiative 1994 (SAFARI 94), a joint South African-German flying campaign, followed SAFARI 92 and focused on the in situ chemical sampling of aerosols and trace gases across the region during the non-biomass burning season.

These initiatives, together with others addressing independent ecological and climate issues, have contributed much to our understanding of discipline-specific objectives. However, linkages between the controlling and impacted processes were given less attention. In particular, past scientific accomplishments have led to the formulation of questions that require more synthetic, integrated and interdisciplinary research. It is on this foundation that SAFARI 2000 is being developed.

The initial motivation for SAFARI 2000 evolved from several IGBP/START regional workshops that identified the global-change science priorities for the region. This led to a series of stakeholder workshops held in the summer of 1998. At a National Science Foundation (NSF)-sponsored workshop on Southern African Land-Atmosphere-Biosphere Interactions, held at Blydepoort, South Africa in July, 1998, more than 70 participants from 12 countries met to begin shaping the core elements of SAFARI 2000. Specific questions about aerosols and trace gases were developed with the following progression in mind: sources; transformations; patterns; responses; and interactive processes.

Presently, a number of precursor activities set the stage for SAFARI 2000. These include: ARREX (South Africa¹s Aerosol Recirculation and Rainfall Experiment); INDOEX (Indian Ocean Experiment); AERONET (NASA¹s Aerosol Robotic Network); SHADOZ (NASA¹s Southern Hemisphere ADditional OZonesondes Project) and IDAF (IGAC DEBITS (Deposition of Biogeochemically Important Trace Species) Africa project). The IGBP LUCC/START Miombo Network is helping coordinate efforts that concern the miombo woodlands in the northern half of the study region. The NASA Land-Cover/Land-Use Change and Ecology programs have a number of studies currently underway in southern and central Africa.

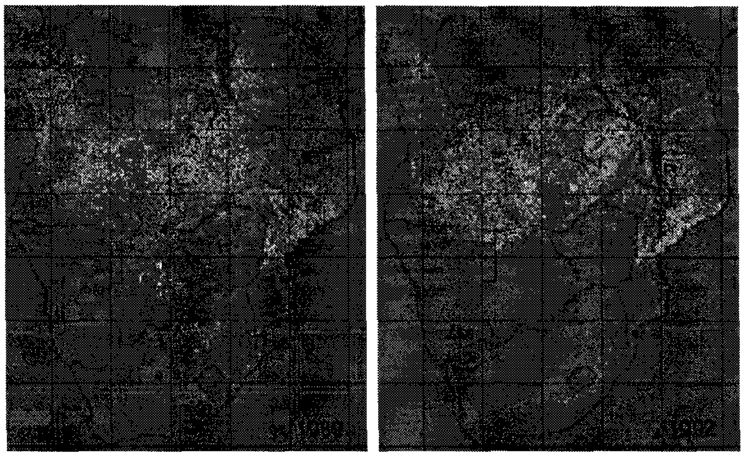


Figure 2. Southern African Biomass Burning during August/September, 1992 with SAFARI 2000 core sites indicated.

SAFARI 2000

SAFARI 2000 will be conducted over a three-year period starting in the second half of 1999, with major field campaigns during 1999 and 2000. It will focus on the following science components: terrestrial ecosystems and biogeochemical transformations, land-cover and land-use change, fire disturbance, pyrogenic, biogenic and industrial emissions and their transport, aerosol and cloud characterization and interactions both over land and oceans, and atmospheric chemistry and deposition.

Multiple tools will be used to achieve the Initiative's goals. The existing scientific database and regional infrastructure will be exploited, and be augmented by new in situ and remote measurements and comprehensive modeling efforts. In situ measurements will be largely clustered around core field sites that are representative of major regional land-cover variants, have a scientific heritage, and are subject to long-term preservation. Field sites near Mongu, Zambia, and Skukuza, South Africa, will anchor the ground network. These two sites are currently part of NASA's Global Land Cover Test Sites, EOS Land Validation Core Sites, and AERONET programs. A walk-up tower at each site will allow above-canopy access to investigators (Figure 3). Several other scientific towers in the region will also be employed.

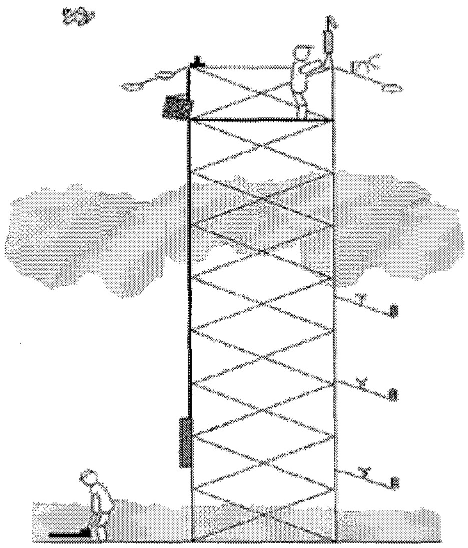


Figure 3. Schematic of EOS validation tower set up that will be deployed at Mongu, Zambia, and Kruger National Park, South Africa.

Both periodic and large episodic aircraft campaigns will complement the ground measurements. The SAFARI Core sites will be overflown periodically by light aircraft hosting a small set of remote sensing instruments. More intensive aircraft measurements will occur during Intensive Field Campaigns (IFC) scheduled for August/September 1999, and February 2000, and August/September 2000. The strategy is to integrate a comprehensive wet season assessment with dry season assessments. At least two aircraft featuring extensive aerosol, trace gas, and ground observation sensors will be used during these periods. In addition, the NASA ER-2 will carry a range of simulation sensors, including MAS, AirMISR, CLS, SSFR, S-HIS, and MOPITT-A during the IFC in August/September of 2000. A full suite of satellite land and atmosphere products from the AM, Landsat 7, SeaWiFS, NOAA/AVHRR, and other satellites will be employed.

The various data sets derived from this array will help provide the initialization and validation sets required for various modeling activities. The research will incorporate models of ecosystem processes such as biophysical energy and water exchanges with the atmosphere, biogeochemical cycling, and plant demographics, as well as mesoscale atmospheric models. The observations and modeling will extend across spatial scales from plot to landscape and region scales and across time scales from hours to weeks to years.

Based on lessons learned from previous campaigns, data integration and archiving are actively being planned. A fully open data distribution policy is envisioned, with incentives for rapid data reduction and turnaround. Information from SAFARI 2000 activities will be disseminated regionally and internationally via the Internet as well as through the distribution of CD-ROMs. A mirror World Wide Web site with SAFARI-only data will likely be set up in the region. These efforts will help scientists achieve the goal of results synthesis by 2001.

SAFARI 2000 provides northern and southern hemisphere researchers opportunities for capacity recognition as well as the transfer of technology and expertise from North to South and perhaps, more importantly, from South to North. An important component of the SAFARI 2000 objectives is model and satellite product evaluation by local experts, as well as the promotion of informed use of these models and data by regional scientists.

Earth Observing System Synthesis

The ambitious goals of SAFARI 2000 will be achieved with the help of the comprehensive data sets expected from the new generation of EOS sensors. High-spatial-resolution sensors such as ASTER on AM-1 and ETM+ on Landsat 7 will detect fine-scale land-cover change and use, and facilitate the scaling of point and short-transect measurements over much larger areas. Likewise, MODIS, SeaWiFS, and AVHRR will be used for full regional views and retrospective analysis. Particularly encouraging is the anticipated ability of MODIS to more accurately detect thin cirrus clouds, fire temperature, areal extent, and thermal energy, and detect surface features through the occasionally pervasive smoke layers. The highly variable aerosol forcing problem will largely be attacked with the accurate aerosol and 3-D cloud products expected from MISR. This sensor may also help resolve savanna and woodland variability through its bidirectional sampling capabilities. Finally, MOPITT will help resolve large-scale source, sink, and transport questions associated with carbon monoxide and methane emissions.

In return, a significant contribution to EOS validation will be made by SAFARI 2000. In addition to planned regional activities by members of the MODIS, MISR, ASTER, and MOPITT instrument teams, three AM-1 validation investigations are funded in the region. These three activities include: Southern African Validation of EOS (SAVE): Coordinated Augmentation of Existing Networks, J. L. Privette (PI); Vertical Profiles of Carbon Monoxide and Other Gases in the Troposphere, P. C. Novelli (PI); Biomass Burning and Emission of Trace Gases and Aerosols: Validation of EOS Biomass Burning Products, W. M. Hao/D. E.

Ward (PIs). The AERONET program will capture aerosol information with a relatively dense deployment of sunphotometers. Together, these groups will coordinate ground and air measurements around the Core Sites to validate both atmospheric and surface satellite products. When possible, investigators will leverage their analyses on independently gathered data sets. Standing acquisition requests have been negotiated with the respective instrument teams for products at each of the Core Sites. An extensive set of airborne in situ measurements will be made over the various surface sites and coordinated with the EOS satellite overpasses. In addition to the NASA ER-2, the U.S. will support the University of Washington CV-580 for in situ measurements of clouds, aerosols, trace gases, and radiation. This large range of measurements combines to make SAFARI 2000 the largest coordinated validation activity planned for AM-1.

The Next Steps

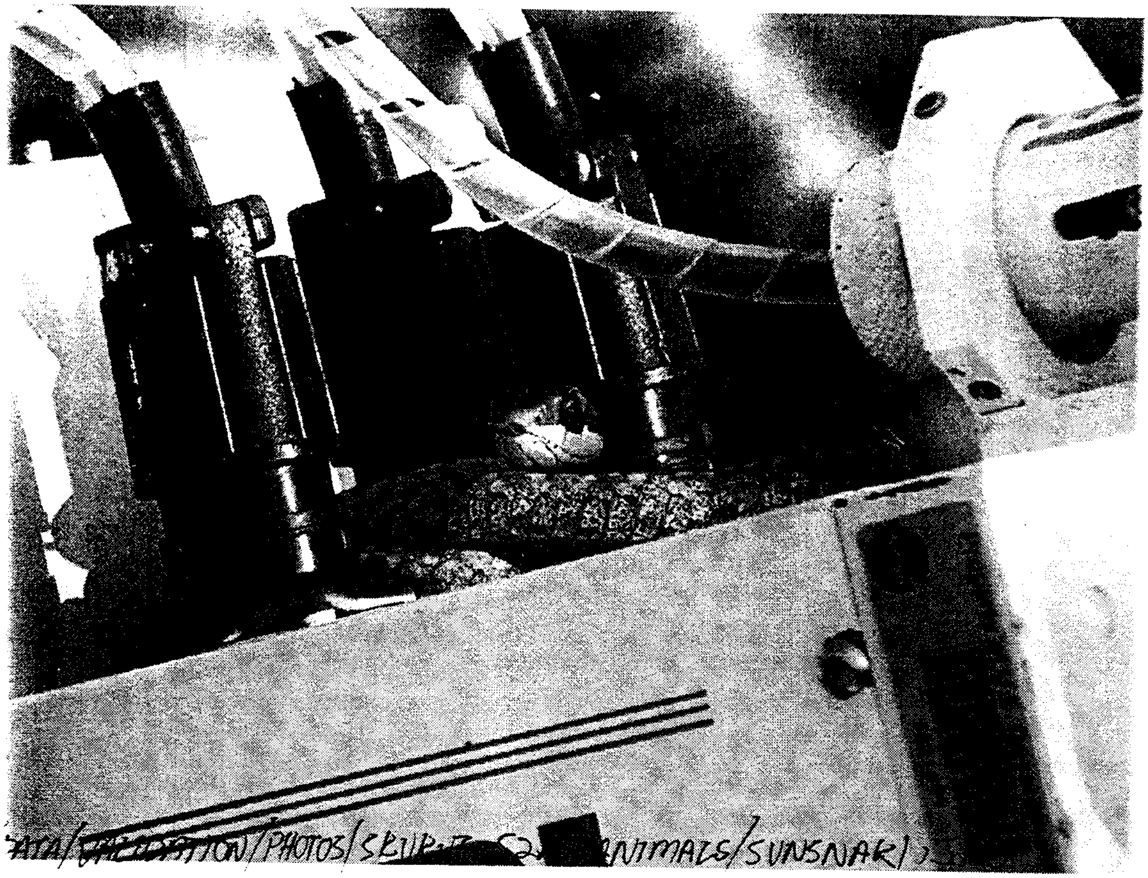
SAFARI was chosen as a rallying acronym for the Initiative, centered on the millennium, and with a heritage of international collaboration within the region. It is envisaged that through open participation in SAFARI 2000, new in situ data collection combined with advances in the modeling of the biogeophysical systems and improvements in satellite monitoring, will lead to an improved understanding of regional and global environmental change in southern Africa.

Government and scientific agencies from the U.S., Europe and Southern Africa have been briefed on the plans for SAFARI 2000. The SAFARI 2000 Science Plan is under development and should be ready for open distribution in early 1999. The outline of the Science Plan, developed at the Blydepoort planning meeting, received preliminary endorsement at the BIBEX Meeting held in Seattle, Washington, USA, in August, 1998, and will be presented to the IGAC steering committee in late spring of 1999.

The anticipated schedule of SAFARI 2000 milestone events is as follows:

February 1999: Science Plan distribution
July 1999: Second SAFARI 2000 workshop in Gaborone, Botswana **August/September 1999:** First Intensive Flying /Ground Campaign (dry season)
February/March 2000: Second Intensive Flying /Ground Campaign (wet season)
April 2000: Third SAFARI 2000 workshop, location TBD
August/September 2000: Third Intensive Flying/Ground Campaign (dry season)

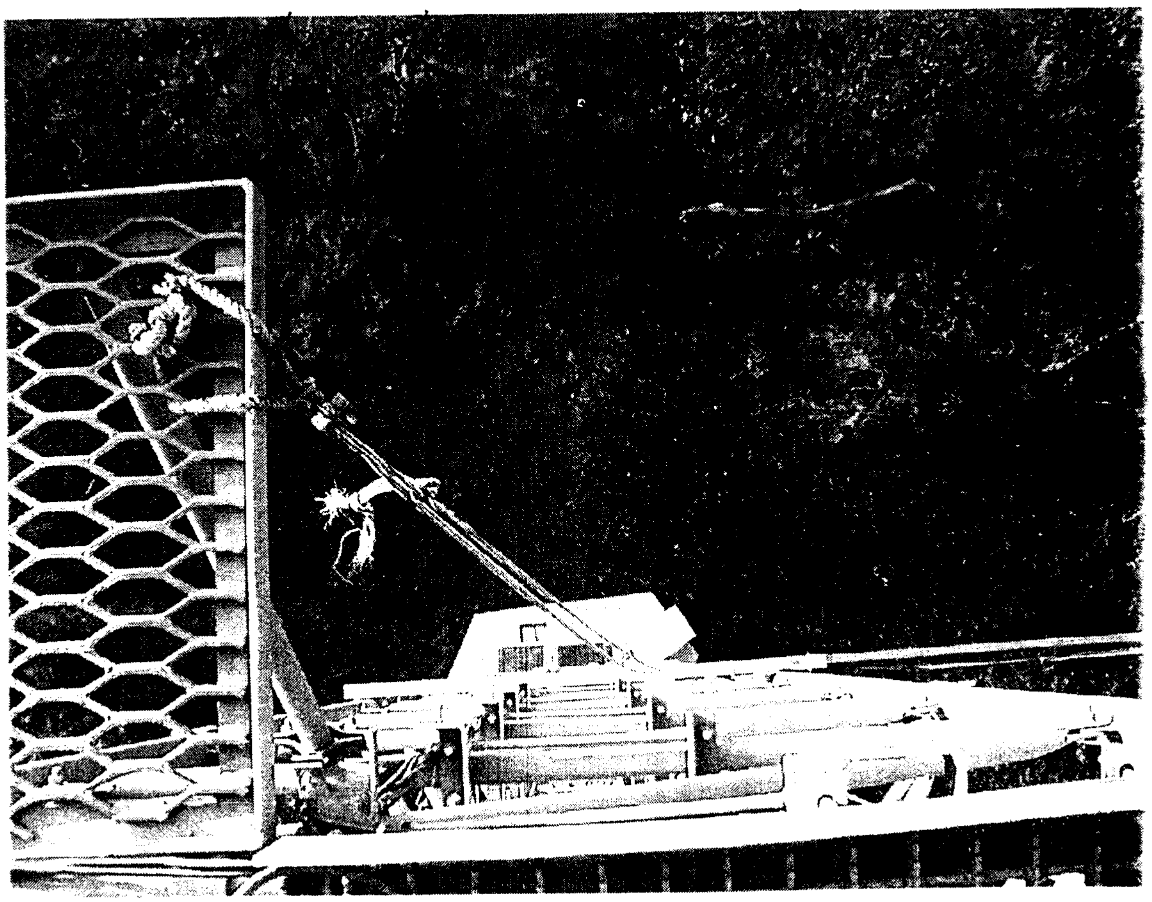
The SAFARI 2000 initiative is open to international participation. Although no explicit core funding is available to U.S. investigators, various funding programs have expressed interest in entertaining SAFARI 2000 proposals submitted through normal funding channels. For further information on SAFARI 2000, please contact the authors and/or visit the SAFARI 2000 World Wide Web page - http://safari.gecp.virginia.edu

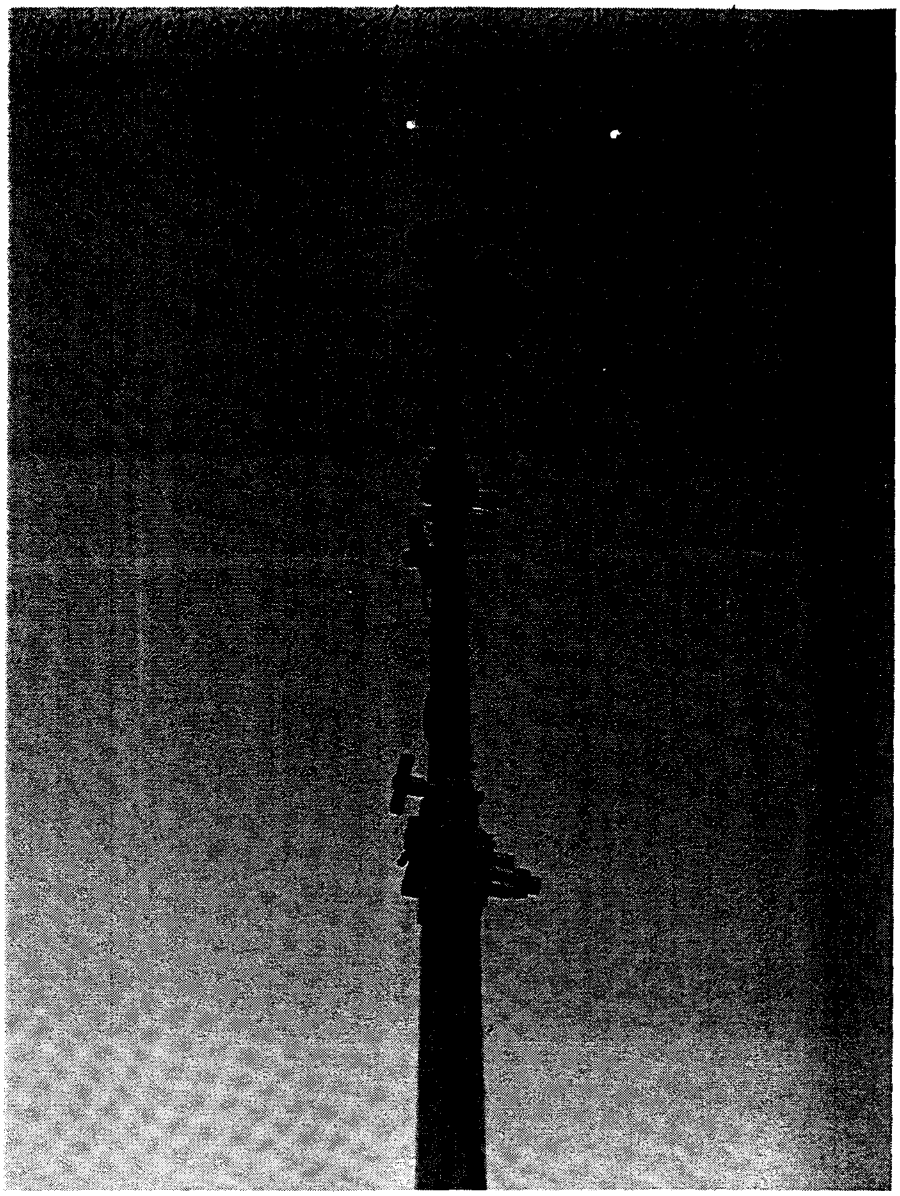


ATA/VALIDATION/PHOTOS/SKUK... S2K/ANIMALS/SUNSNAR/...

DATA/VALIDATION/PHOTOS/SKUKUZA-S2K/LAST_SET/DSC00007.JPG

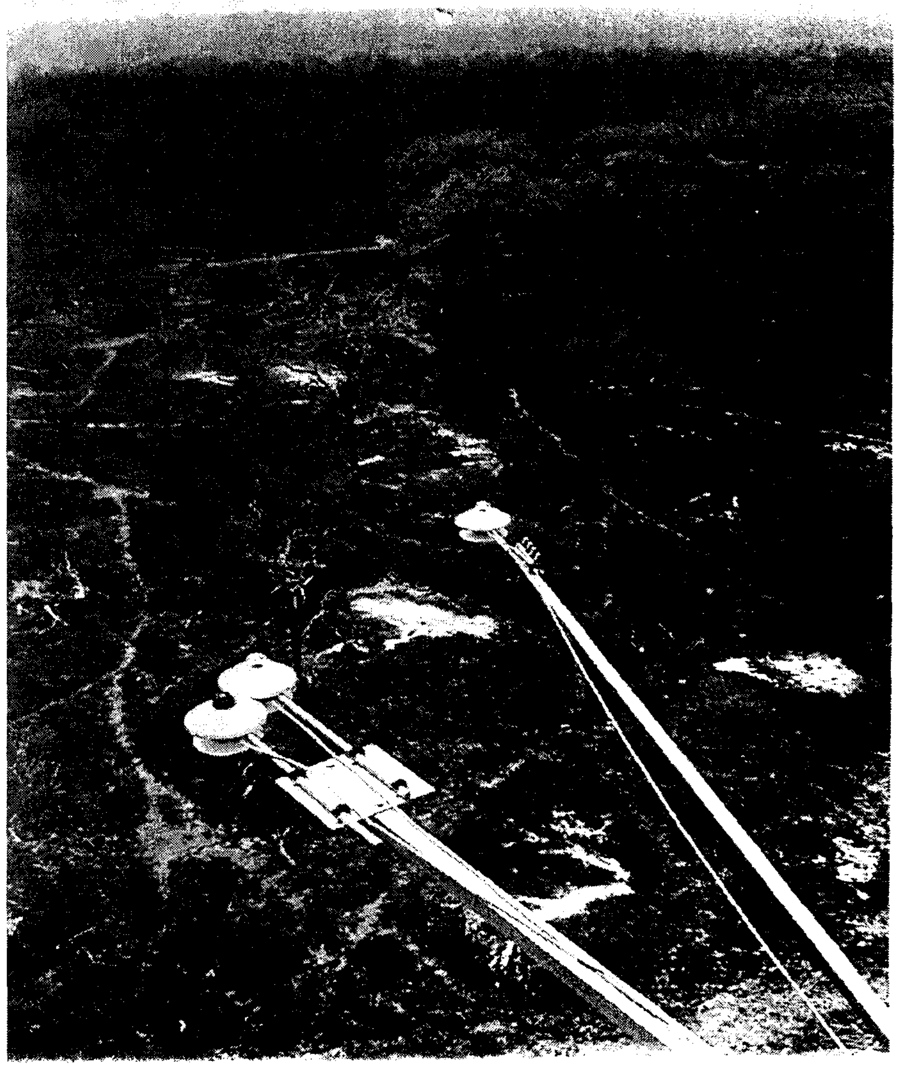
/DATA/VALIDATION/PHOTOS/SKVKVBA_S2K/THINGS/CIMELpix/2NST&RUN

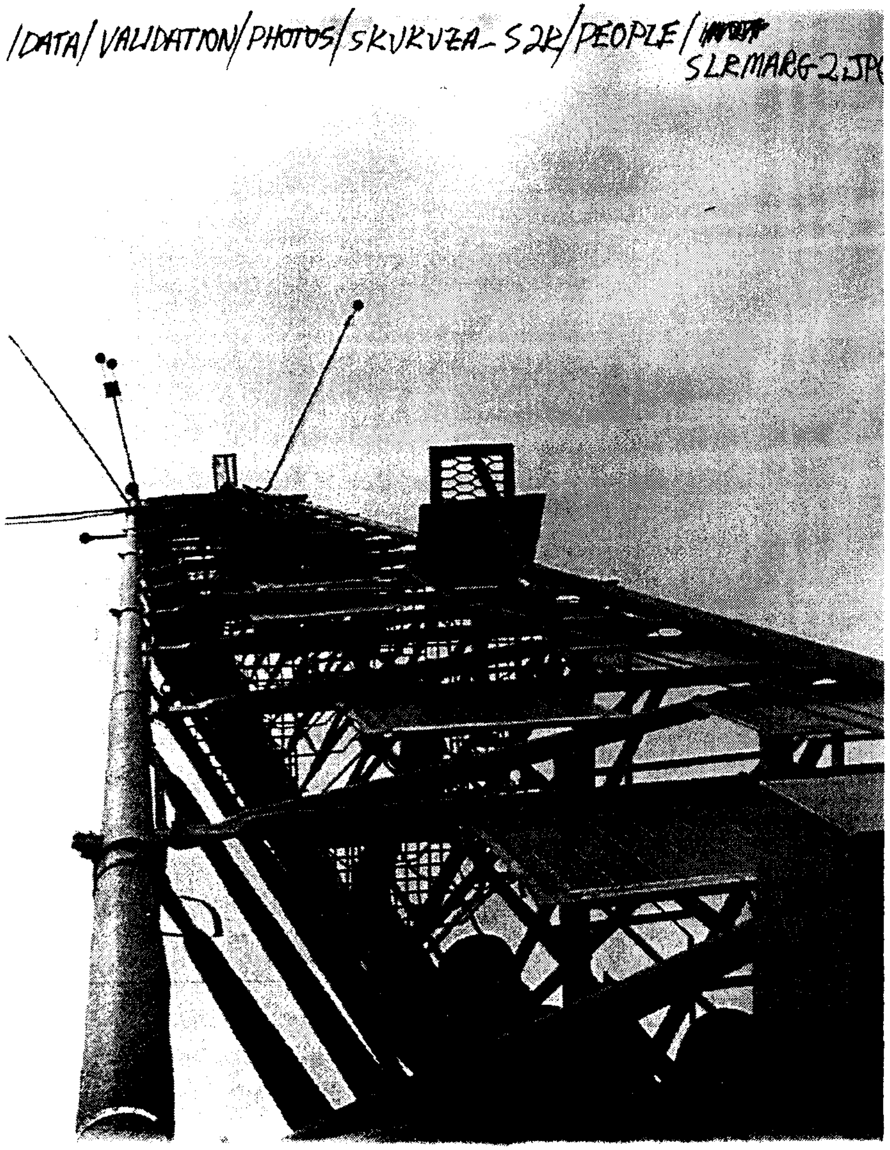


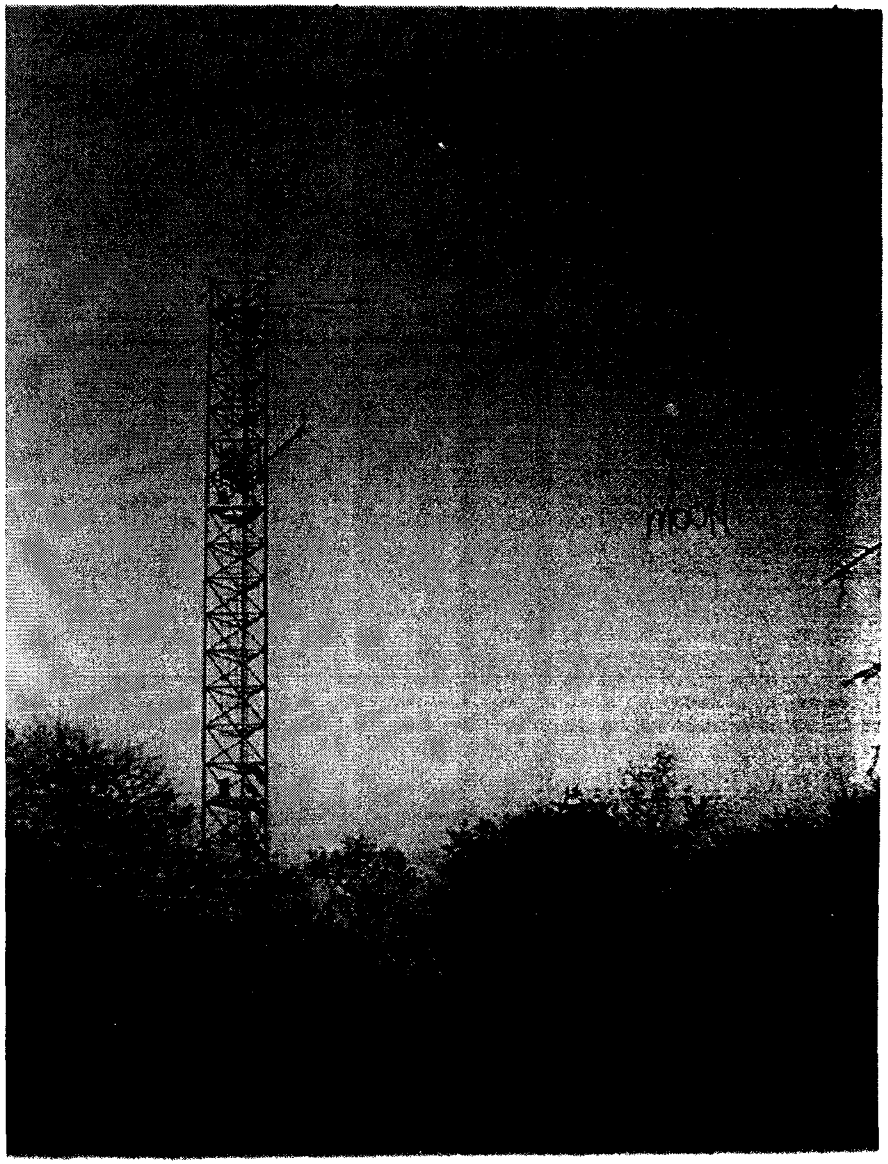


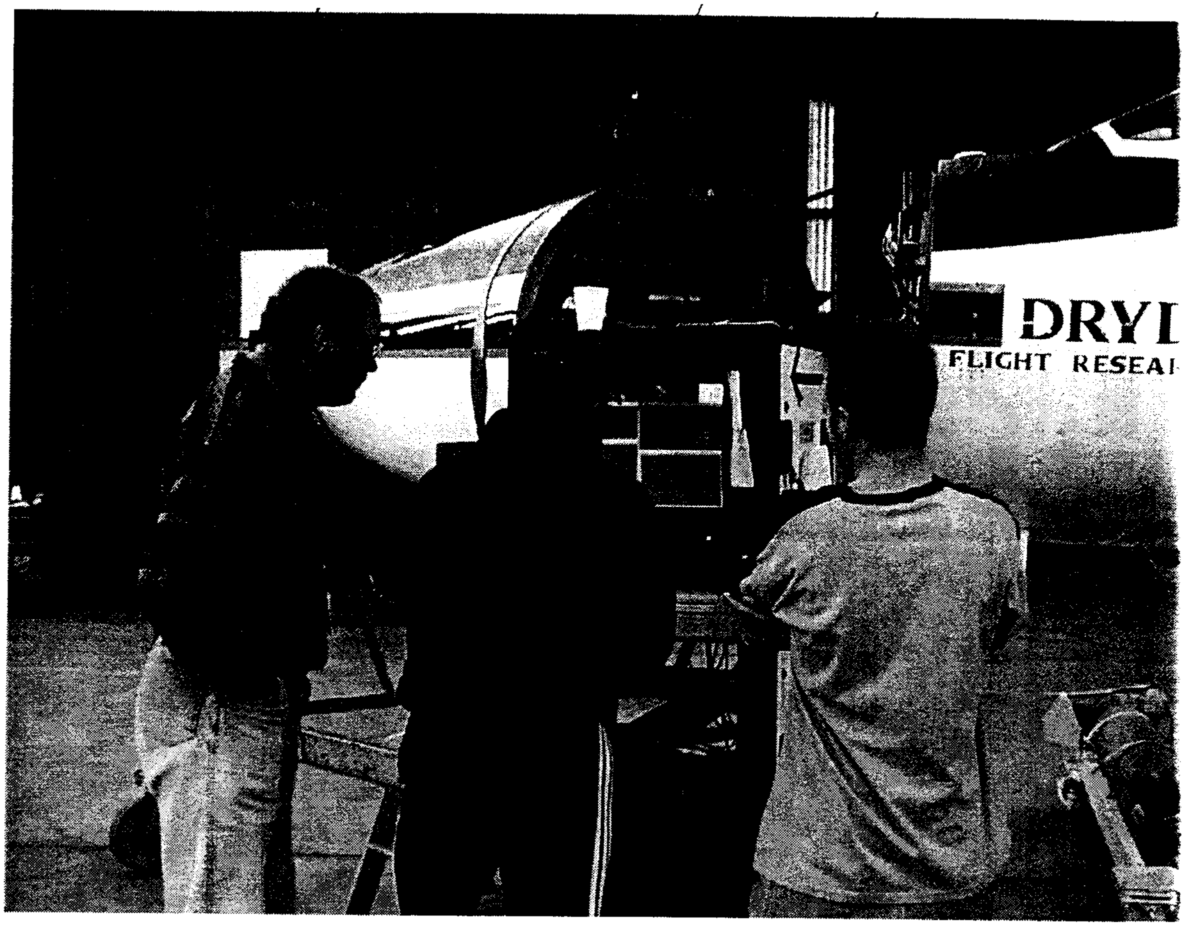
/DATA/VALIDATION/PHOTOS/[illegible]/THINGS/SOLRTWR3.JPG

DATA/VALIDATION/PHOTOS/SKUKUZA_SDK/PLACES/TWRBURN2.JPG



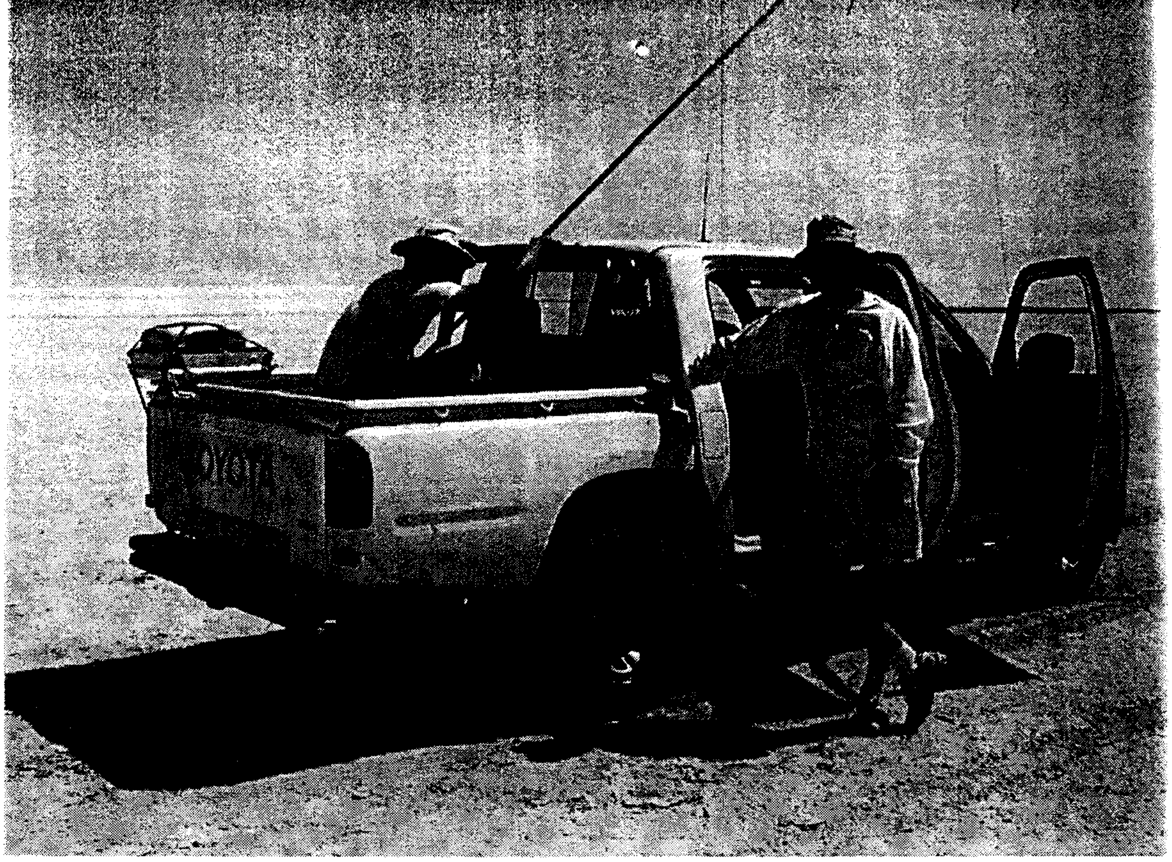

/DATA/VALIDATION/PHOTOS/SKUKUZA-S2K/PEOPLE/
SLRMARG 2.JPG


MOON

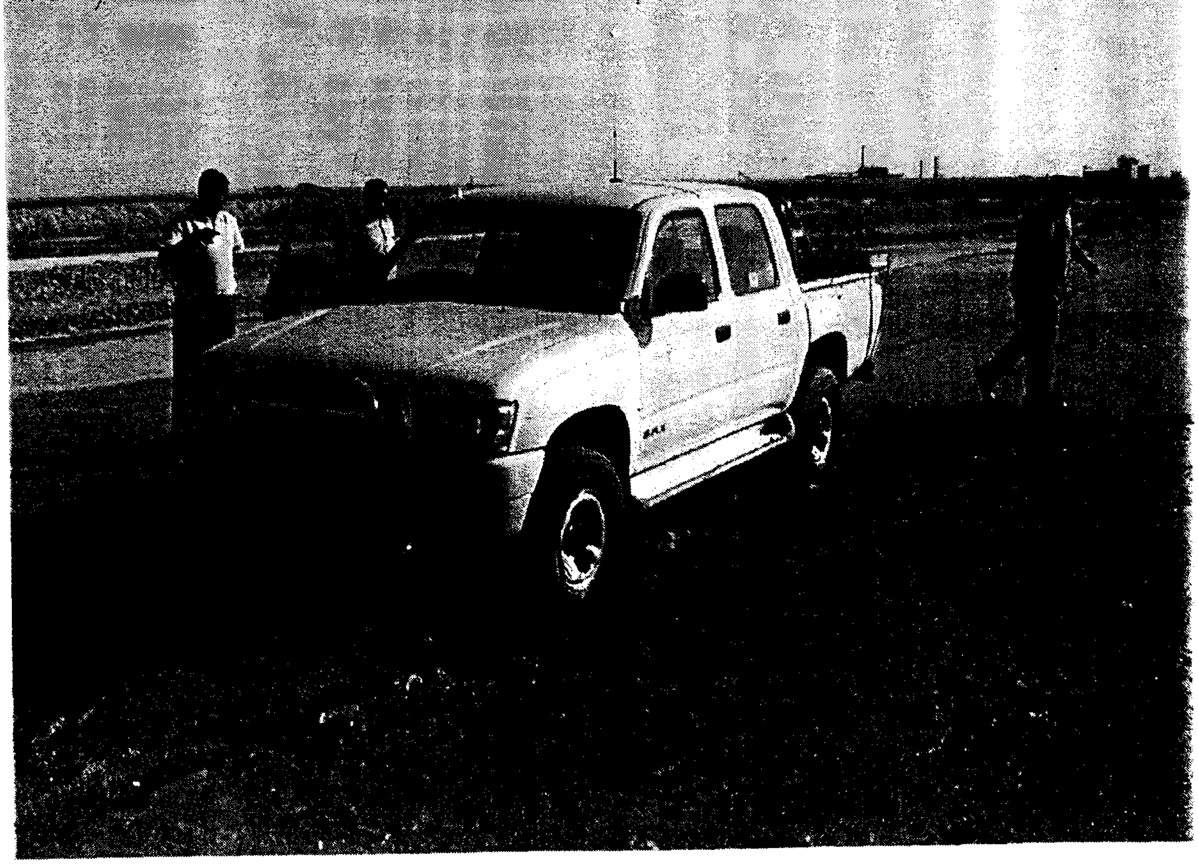


/DATA/VALIDATION/PHOTOS/SKUKUZA_S2K/TAINGS/HOTSPOT1.JPG

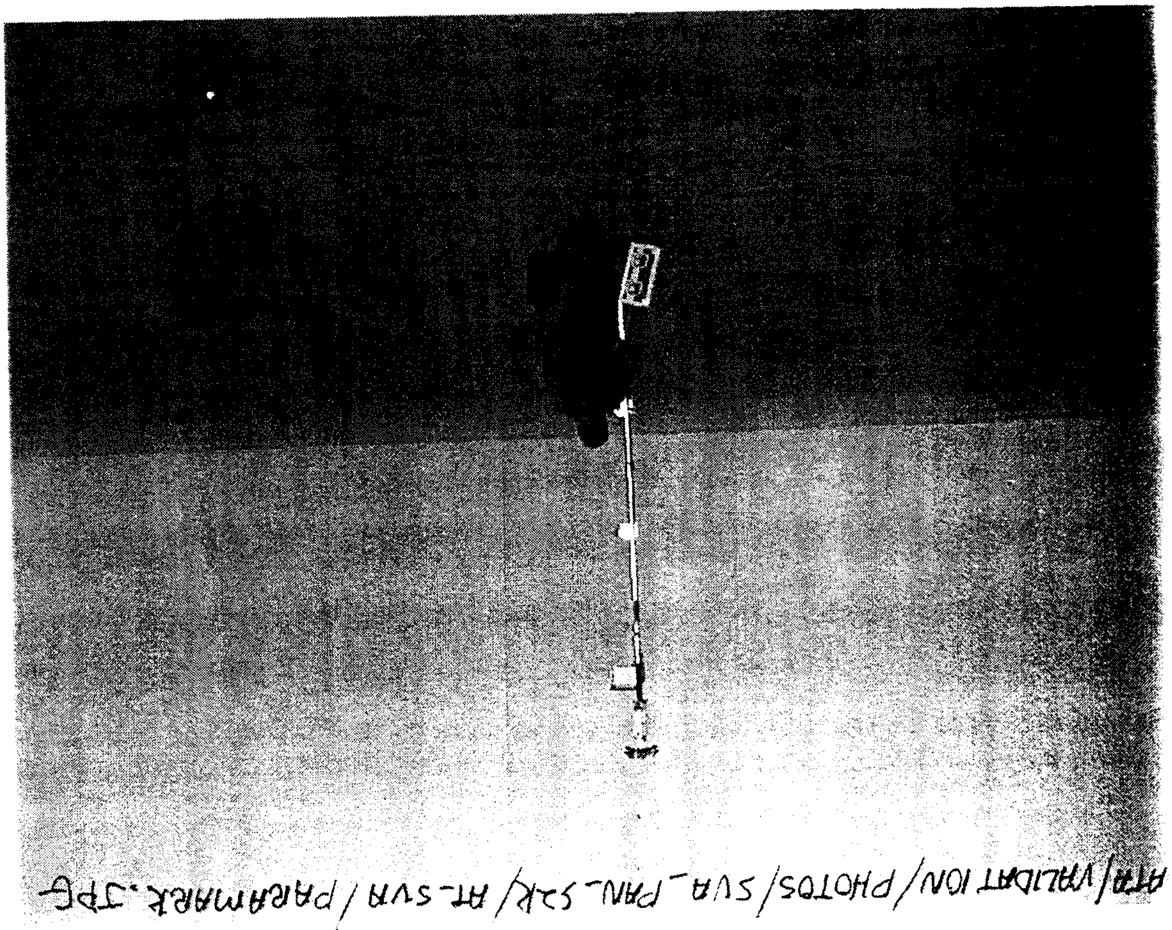
/DATA/VALIDATION/PHOTOS/SVA-PAN-S2R/AT-SVA/PANBURKY.JPG



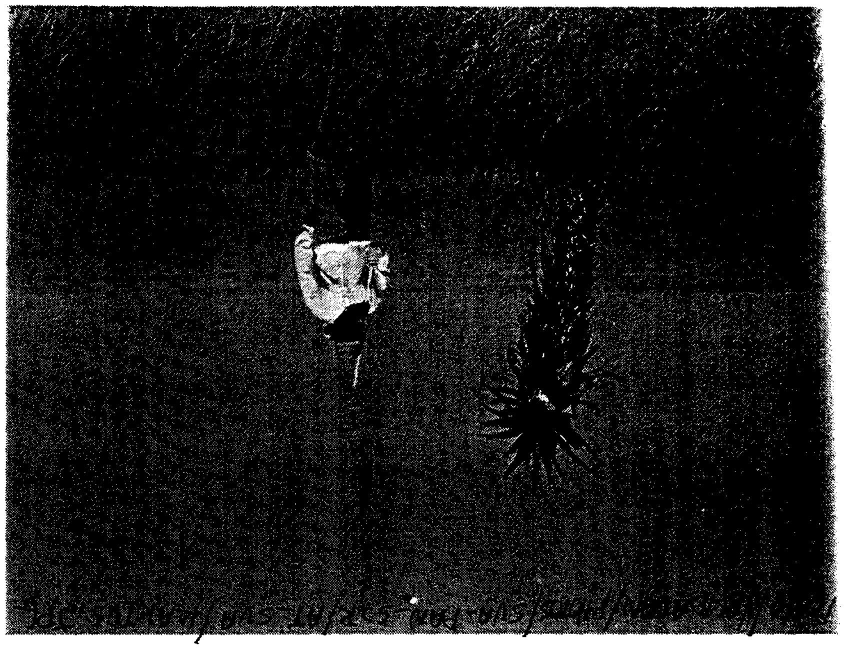
/DATA/VALIDATION/PHOTOS/SVA_PAN_S2R/AT_SVA/STUKTRUK.JPG

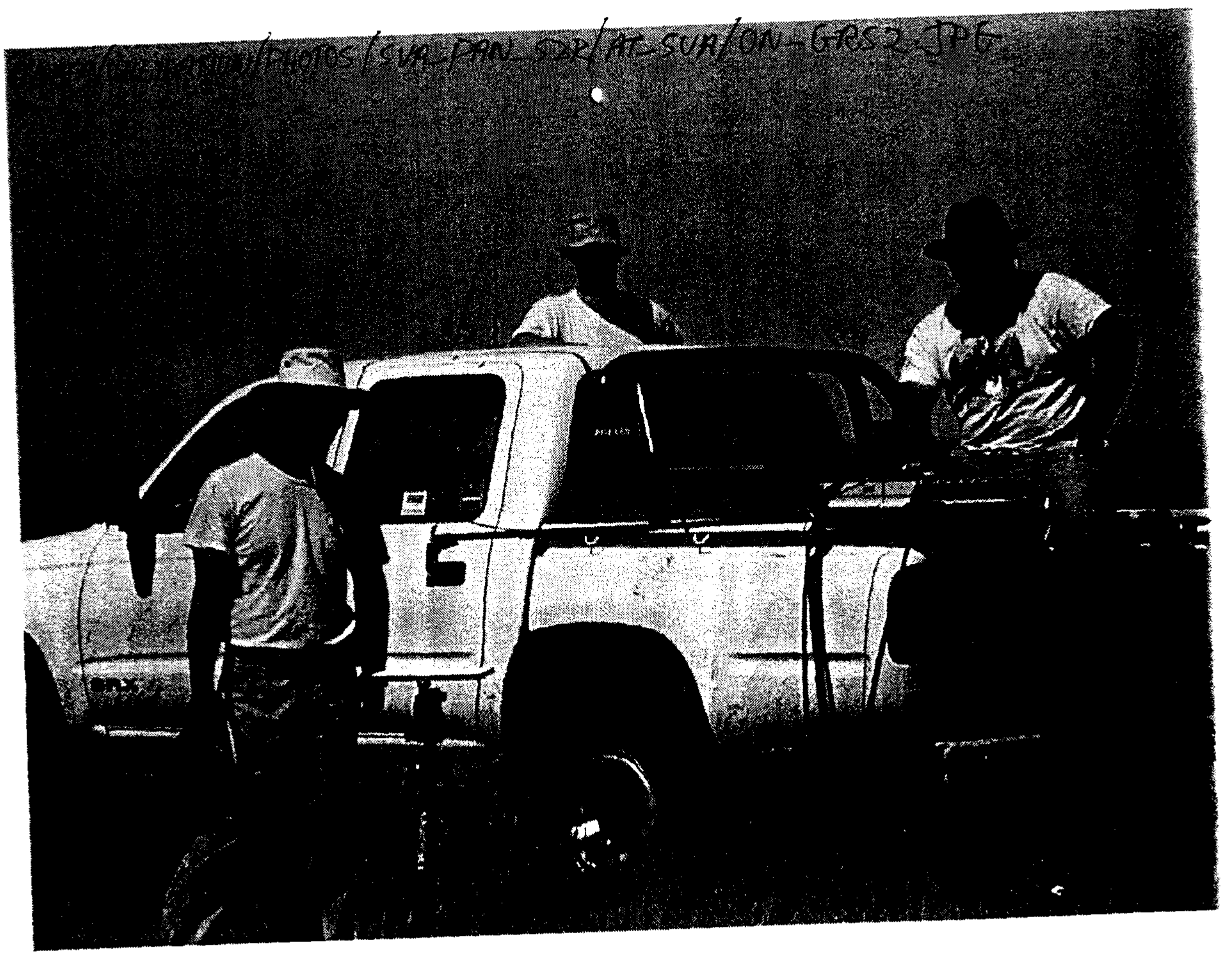


/DATA/VALIDATION/PHOTOS/SVA_PAN_S2K/AT_SVA/WOLFGFAS.JPG



ATA/VALIDATION/PHOTOS/SVA_PAN_S2K/AT_SVA/PARAMARK.JPG




PHOTOS/SVA_PAN_S2R/AT-SVA/ON-GRS2.JPG

/DATA/VALIDATION/PHOTOS/SVA_PAN_52K/AT_SVA/PETE_ABM.JPG